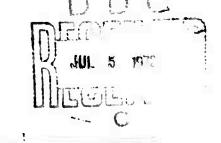
R-915/1-ARPA May 1972

Supplemental Global Climatic Data: January

C. Schutz and W. L. Gates



A Report prepared for ADVANCED RESEARCH PROJECTS AGENCY

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DOCUMENT CONTROL DATA 20. REPORT SECURITY CLASSIFICATION 1. ORIGINATING ACTIVITY UNCLASSIFIED 2b. GROUP The Rand Carporation 3. REPORT TITLE SUPPLEMENTAL GLOBAL CLIMATIC DATA: JANUARY 4. AUTHOR(S) (Last name, first name, initial) Schutz, C. and Gates, W. L. 6g. TOTAL NO. OF PAGES 6b. NO. OF REFS. 5. REPORT DATE April 1972 50 11 7. CONTRACT OR GRANT NO. 8. ORIGINATOR'S REPORT NO. DAHC15-67-C-0141 . R-915/1-ARPA 90. AVAILABILITY/LIMITATION NOTICES 9b. SPONSORING AGENCY Defense Advanced Research Projects DDC- A Agency IO. ABSTRACT 11. KEY WORDS The global distributions of the surface Meteorology albedo for January, the planetary albedo Climate for January, and the total precipitation Computer Simulation for December, January, and February are presented as a supplement to the January data previously published (Schutz and Gates, 1971). A number of refinements of the high-latitude sea-surface temperature data have also been made, and the revised global January distribution is given. All data are presented on a global grid of 4-deg latitude and 5-deg longitude, as in the past, and are given in the form of both tabulated values and machine-analyzed maps. These data will be used as a guide in Rand's evaluation of climate simulations based on the Mintz-Arakawa general circulation model.

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II

PREFACE

Meteorological studies suggest that technologically feasible operations might trigger substantial changes in the climate over broad regions of the globe. Depending on their character, location, and scale, these changes might be both deleterious and irreversible. If a foreign power were to bring about such perturbations either overtly or covertly, either maliciously or heedlessly, the results might be seriously detrimental to the security and welfare of this country. So that the United States may react rationally and effectively in response to such actions, it is essential that we have the capability to (1) evaluate the consequences of a variety of possible actions that might modify the climate, (2) detect trends in the global circulation that presage changes in the climate, either natural or artificial, and (3) determine, if possible, means to counter potentially deleterious climatic changes. Our possession of this capability would make incautious experimentation unnecessary, and would tend to deter malicious manipulation. To this end, the Advanced Research Projects Agency initiated a study of the dynamics of climate to evaluate the effect of environmental perturbations on climate. This Report is a technical contribution to the study.

An important part of the Rand/ARPA research program on the dynamics of climate is the evaluation of the accuracy of simulations of the global climate given by numerical solutions of models of the general atmospheric circulation (in particular, the Mintz-Arakawa model).

A systematic evaluation requires a knowledge of the global distribution of many climatic variables. In a previous Rand report by C. Schutz and W. L. Gates, (Global Climatic Data for Surface, 800 mb, 400 mb: January, R-915-ARPA, January 1971) the January distribution of pressure, temperature, humidity, wind, and annual precipitation was presented together with the associated distributions of the elements of the global radiation and hydrologic balances. At this time it is possible to add to these data the normal surface albedo and the planetary albedo as measured from space. Our continuing research has also

made it possible to refine the original presentation of sea-surface temperature near the poles and to include the precipitation distribution for December, January, and February.

The supplementary data presented here are part of a continuing effort to gather in one place and in a common format the most representative global climatologies of selected seasonal meteorological variables.

SUMMARY

The global distributions of the surface albedo for January, the planetary albedo for January, and the total precipitation for December, January, and February are presented as a supplement to the January data previously published (Schutz and Gates, 1971). A number of refinements of the high-latitude sea-surface temperature data have also been made, and the revised global January distribution is given. All data are presented on a global grid of 4° latitude and 5° longitude, as in the past, and are given in the form of both tabulated values and machine-analyzed maps. These data will be used as a guide in Rand's evaluation of climate simulations based on the Min+2-Arakawa general circulation model.

ACKNOWLEDGMENTS

Appreciation is extended to R. C. Alexander for his efforts in developing the data on sea temperatures and ice limits at high latitudes. Thanks are also due R. L. Mobley and A. B. Nelson for reducing these data to the desired format.

CONTENTS

PREFACE	iii
SUMMARY	ν
ACKNOWLEDGMENTS	vii
Section 1. INTRODUCTION	1
2. DATA SELECTION AND PROCESSING	3 4
Albedo	4
3. GLOBAL CLIMATIC ANALYSES	9
4. ZONALLY AVERAGED DATA	15
5. GLOBAL DATA TABULATIONS	21
REFERENCES	41

1. INTRODUCTION

The data presented in Schutz and Gates (1971) describe the January global distribution of the primary climatic elements of pressure, temperature, wind, and moisture, together with a number of components of the surface heat and water balances. The supplementary data presented here for the albedo and precipitation and the refinements to our original presentation of sea-surface temperature are part of a continuing effort to present the best climatologies available. These data will be used in the evaluation of climate simulation experiments based on numerical general circulation models, the Mintz-Arakawa model in particular. A documentation of this model is now available (Gates, et al., 1971).

Despite an exhaustive search for the best possible January data, some variables were not readily available for the compilation of Schutz and Gates (1971); other variables have been updated at Rand or obtained from new reference material. The new January data presented in this Report are summarized in Table 1.1.

Section 2 discusses the data selection and processing. Section 3 presents a global analysis of each variable selected. The corresponding distribution of the zonal averages and the global average values are given in Section 4, and Section 5 gives tabulations of the associated grid-point data. The asterisks (*) in the grid-point tabulations denote regions with missing data. These regions correspond to the blank or "no data" areas of the analyzed maps and zonal averages. An exception occurs in the sea-surface temperature data in Sections 3 and 5, where the letter "I" is also included to denote the location of sea ice.

Table 1.1
IDENTIFICATION OF SUPPLEMENTARY CLIMATIC VARIABLES FOR JANUARY

Data or Variable	Unit	Source	Record Period	Pages
Temperature (sea surface)	deg C	Washington and Thiel (1970); U.S. Navy Hydrographic Office Atlases (1944, 1957, 1958)	Ипкло мп	9, 15, 21
Dec-Jan-Feb Precipitation	mm/day ⁻¹	M611er (1951)	Unknown	10, 16, 25
Annual Precipitation	mm/day ⁻¹	Lvovitch and Ovtchinnikov (1964)	1950-1956 (?)	,, 29 (revised)
Albedo Surface Planetary	Fractions Fractions	Posey and Clapp (1964) (c)	Unknown ^b 	11, 17, 33 12, 18, 37

^aThe three numbers in this column denote the page numbers of the global map analyses, the zonal averaged data, and the global data tabulations.

b A long unknown period of record (from several sources).

CData from unpublished maps by T. H. MacDonald, "ESSA 7 Albedo Data," Radiation Branch, National Environmental Satellite Center, Washington, D.C., January 1969.

2. DATA SELECTION AND PROCESSING

The processing or manipulation of each new source of January data identified in Table 1.1 is briefly described below. Although the discussion refers primarily to the data of Section 3, it also applies to the corresponding zonally averaged data of Section 4, as well as the supporting grid-point data tabulations of Section 5.

It should be noted that the previously published data on zonally averaged mean meridional geostrophic winds (Figs. 4.18 and 4.24 of Schutz and Gates, 1971) are erroneous. These data reflect the rounding error in the averaging process, and should be identically zero.

SEA-SURFACE TEMPERATURE

The global distribution of average January sea-surface temperatures shown in Fig. 3.1 is based largely on the data contained in the NCAR publication of monthly averages (Washington and Thiel, 1970). The NCAR data, which apply between latitudes of 66°N and 66°S, were linearly extrapolated by 2.5° of latitude and longitude in the direction of land or ice (interpolated for small islands or narrow peninsulas) and then transferred to the 4° latitude, 5° longitude grid by interpolation. Poleward of 66°N and 66°S, sea temperature and the distribution of sea ice were obtained from U.S. Navy Hydrographic Office Atlases (1944, 1957, 1958). The grid elements containing more than 50 percent sea ice are denoted by "I" in Fig. 3.1. This introduces a bias toward more severe ice conditions. (For example, if 60 percent of an area contains ice of 60 percent concentration, only 36 percent of the area is actually covered by ice.) This bias may partly compensate for the usual bias in the data toward calm, warm weather and ice-free conditions when ships can operate. In high northern latitudes, February sea temperatures were used, which are slightly colder than those of January.*

The U.S. Navy Hydrographic Office Atlases (1957, 1958) show sea temperatures only for February, May, August, and November.

PRECIPITATION

The global distribution of the annual precipitation (Fig. 3.6A of Schutz and Gates, 1971) remains a valuable source of information based on the work of Lvovitch and Ovchinnikov (1964). We also note that in the tabulation of these data (Table 5.6A of Schutz and Gates, 1971), erroneous values were given for the annual precipitation at 90°N and 90°S. These errors have been corrected in Table 5.2A presented here.

The December-January-February distribution of precipitation for the globe (Fig. 3.2) was obtained from visual interpolation onto a 5° latitude, 5° longitude grid from the analysis of Möller (1951). This was followed by linear interpolation to the points of the present grid. Although these data involve some empirical partitioning of the observed annual precipitation similar to that of Jacobs (1968), they are apparently the only global distributions available. The zonally averaged mean precipitation (Fig. 4.2) based on Möller (1951) supplements the previous data (Fig. 4.6B of Schutz and Gates, 1971), which was based on seasonal ocean apportionment extended over the intervening land masses (Jacobs, 1968). Table 2.1 shows partitioning of precipitation data, a technique that may prove valuable in future research.

ALBEDO

The values of mean surface albedo for January shown in Fig. 3.3 were transcribed directly onto the 4° latitude, 5° longitude grid from the data of Posey and Clapp (1964). These data show the measured January albedo for various types and amounts of ground cover, and consider the latitudinal variations of solar angle over the ocean.

The values of mean planetary (world) albedo shown in Fig. 3.4 were measured by the ESSA 7 satellite from 16 August 1968 to 23 June 1969. These data were also transcribed directly onto the 4° latitude, 5° longitude grid.* The reduction processes used to obtain these albedo data from the satellite measurements are discussed in detail in MacDonald (1970).

^{*}From unpublished maps by T. H. MacDonald, "ESSA 7 Albedo Data," Radiation Branch, National Environmental Satellite Center, Washington, D.C., January 1969.

Table 2.1

SEASONAL (QUARTERLY) APPORTIONMENT OF PRECIPITATION, BY 10° LATITUDE ZONES (percent)

		Atlanti	c Ocea	n		Pacific	Ocean			Indian	Ocean	l
Latitude	Dec Jan Feb	March April May	June July Aug	Sept Oct Nov	Dec Jan Feb	March April May	June July Aug	Sept Oct Nov	Dec Jan Feb	March April May	June July Aug	Sept Oct Nov
50°-60°N 40°-50°N 30°-40°N	28 31 33	23 23 26	21 20 16	28 26 25	20 25 31	22 24 27	25 23 21	33 28 21				
20°-30°N 10°-20°N 0°-10°N 0°-10°S	27 25 22 28	20 15 25 38	22 31 29 17	31 29 24 17	29 18 24 33	24 19 24 23	25 32 27 26	22 31 25 18	13 10 22 27	6 12 20 22	57 46 28	24 32 30
10°-20°S 20°-30°S 30°-40°S	22 23 18	22 28 25	36 23 33	20 26 24	32 24 18	22 27 26	23 27 32	23 22 24	30 24 17	27 31 25	25 25 30	26 18 15
40°-50°S 50°-60°S	20 26	26 28	30 26	24 20	22 24	26 29	28 22	24 24 25	22	26 	34 28	24 24

SOURCE: W. C. Jacobs (1968).

3. GLOBAL CLIMATIC ANALYSES

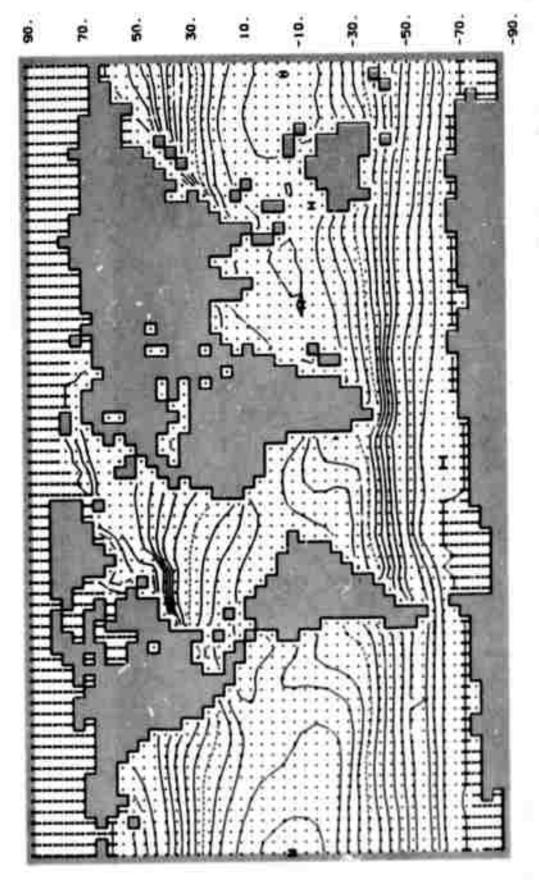


Fig. 3.1 -- Mean January sea-surface temperature in deg C. The analysis interval is 2 deg and the 20-deg C isotherm is dashed. "I" denotes grid elements with sea ice. Deduced from data of washington and Thiel (1970) and Hydrographic Office Atlases (1944, 1957, and 1958).

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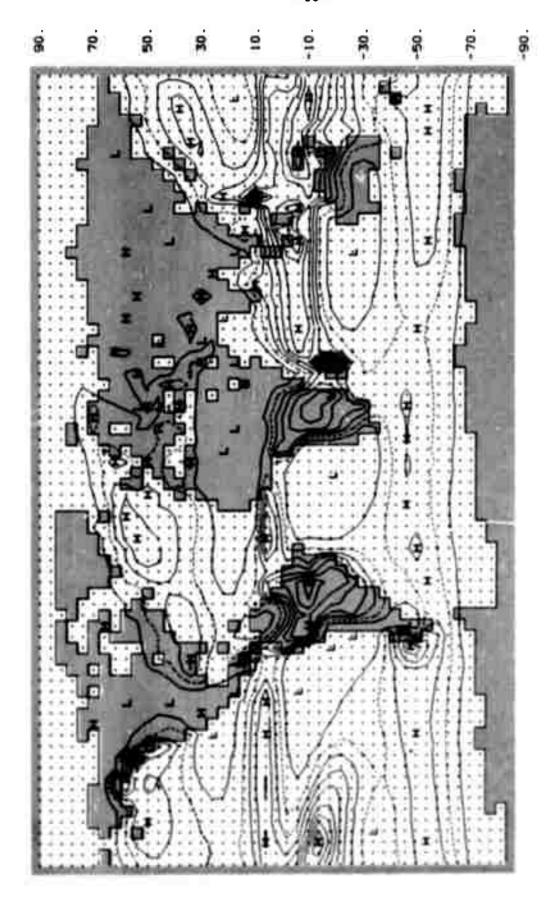


Fig. 3.2 -- Mean December-January-February precipitation in mm/day. The analysis interval is 1.0 mm and the 2.0-mm isoline is dashed. Data from Möller (1951).

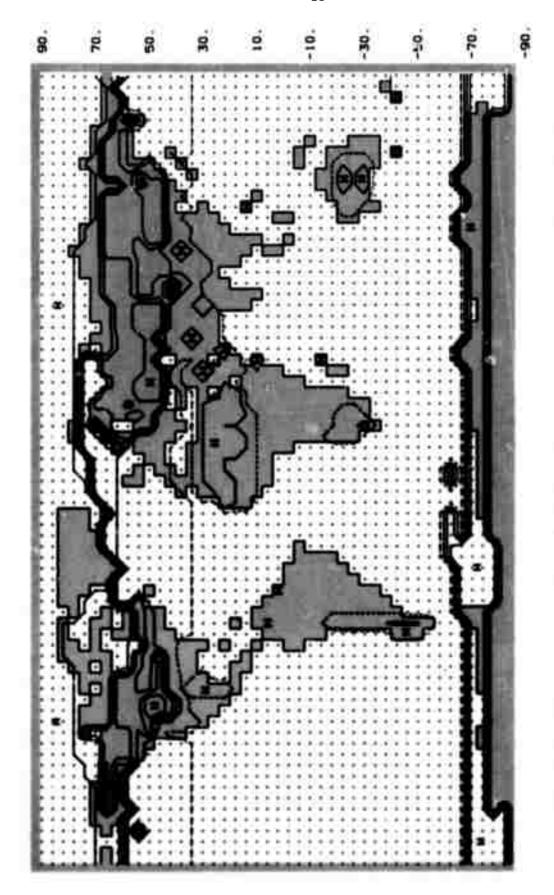


Fig. 3.3 -- Hean January surface albedo (fractions). The analysis interval is 0.1 and the 0.1 isoline is dashed. Computed from data of Posey and Clapp (1964).

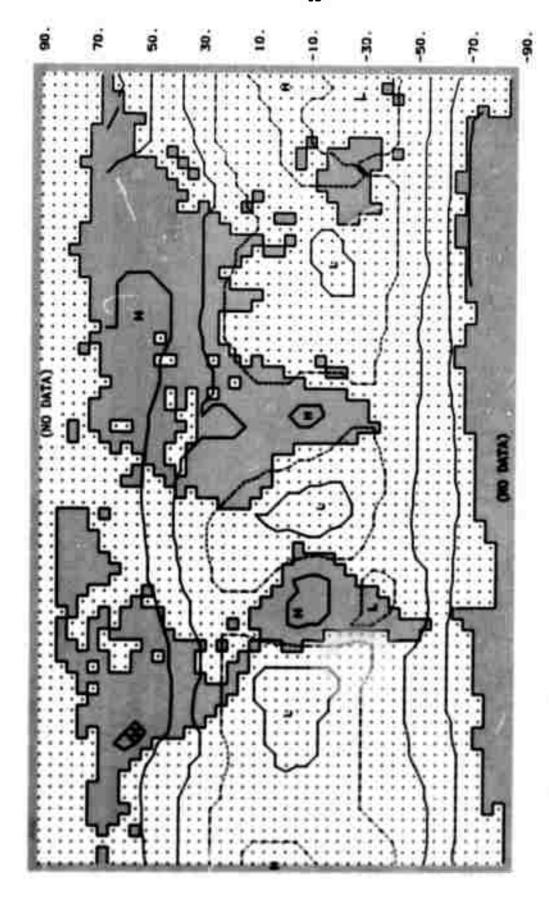


Fig. 3.4 -- Mean January planetary albedo (fractions). The analysis interval is 0.1 and the 0.1 isoline is dashed.

4. ZONALLY AVERAGED DATA

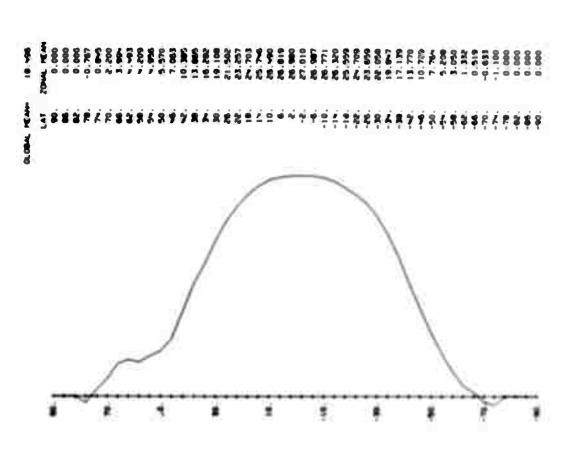


Fig. 4.1 -- Zonally averaged mean January sea-surface temperature in deg C, as found from the data of Fig. 3.1.

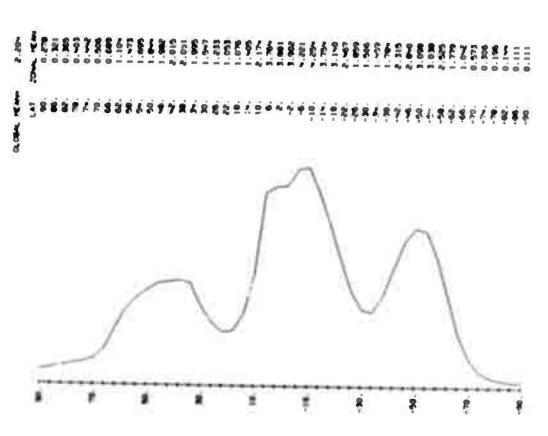


Fig. 4.2 -- Zonally averaged mean December-January-February precipitation in mm/day, as found from the data of Fig. 3.2.

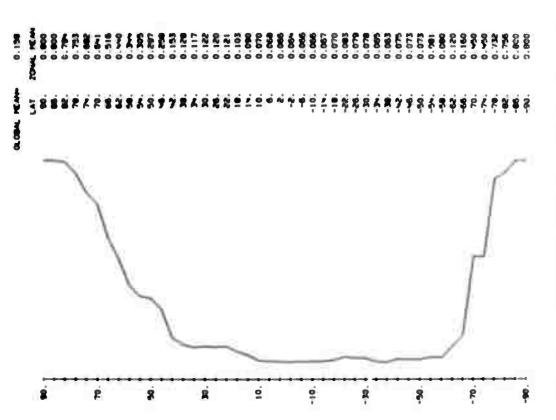


Fig. 4.3 -- Zonally averaged mean January surface albedo (fractions), as found from the data of Fig. 3.3.

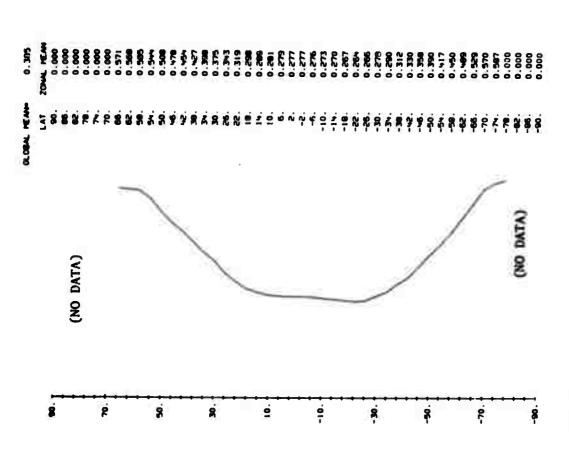


Fig. 4.4 -- Zonally averaged mean January planetary albedo (fractions), as found from the data of Fig. 3.4.

5. GLOBAL DATA TABULATIONS

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46NT	****	**********		**********	ŀ			I				01-1-	-1.00	0	0.20	1.50	•	2.90
2	-		***************************************		Ī						0.90	-1:10	0	0.92	2.02	3.02		4-72
		I	Ī					*****	****	3.48	5.13*	*****	4.26	5.90	7.28	7.50		
200							2.18	*****	7.58	9.80	*****	10.58	11.78	12.23		12.84		7
Ž		*****		******	*****	2	5.70	9.30	13.444	13.44*****	15.70	16.10	16.10	14.24			77.5	
														. 7 . 7	•	12.00	'n	12.04
30N	******	******	*******	1444444	****	4		13 00	44 44					,				
26N8#	******	******	SANCE AND	*****				20.00		:	17.50	•	16.90	₹		19.50	16.40	19.40
2.28	24.848			24. 64.66664664666666666666	İ			04.07	21-12	2 F. 42	21.68	22-12	22.54	22.52	22.36	21.94	21.68	21.50
	26.00					•	47.77	23.88	23.98	j	24.40		25.32	7		24.66	34.50	24.20
	23.10				23.28	24.26	25.04	25.08	25.50	'n	26.40		27.00			24.42	24.00	
Z + I	26.24	26.284	******	*****	:		******	26.40	24. 84		27 30			•	•	74.07	01.07	7).67
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2 6	00	100 17		60.67	42.5	16.07	20.02	27.12	27.52	27.88	21.06	28.16	28.26	28.32	28.32	28.32	28.22	20.00
2 (9				2		27.26	27.46	•	•		28.34		•	28.66			
57		28.66	27.81*	*****	27.23	***	27.80	27.94	•			28.50	•	•			: .	74-07
92	-	28.10	•	27.69	27.58	27.	28.06	28.04					•	•	26.07	:	i.	28.58
)				•			•	•	29.00	÷	ċ	28.60
105	27.90	2	•		22 00	9	22											
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1	26.46	76.05	71.07	20.12	70017	27.90	26.98	26.28*************************		*****	26.30	28.15	28.26	28.70	28.82	28.42	20.66	28-64
200	47.		-	i.	50.07	7	27.22	10000000	1000000	*******	10000001	100001	27.	27.80	27.55	27.46	27.04	27
577	24.32		-	÷	24.28	Ĭ	*******	********	10000001	1000000	1000000	-	7	34.46			70017	Z 1 . 34
265	22.86	7	-	-	-	i	********	****	-					*****	70.07	72.80	23.E4	20.92
														72.40	24.86	24.10	24.00	24.10
308	21.20	9.0	0			0.80	1000000						- 3		,			
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8	5.6	5.4	Š		,		16 91		٠.						÷	29.63	20.02	19.61
N	2.3	2.2	2			, ,	٠,			77-01		9.51	•	•	÷	19.20	17.06**	*****
•	8.8		-	41.0	0.70			01.01	97.61	100	70-1		15.80	•	'n	15.24	*****	15.80
			•		•	5	•			11.22	8.11	11.66 12.28 1	ż	12.82	12.76	12.86	12.99	13.36
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	•	•	•	71.7	•	•	29.2		3.06	•				4-40	A. 28			
570	•	•	•	0.52	•	•	98.0		1.14				2.04	2.24				7700
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TABLE 5.1 JAN SEA-SURFACE TEMPERATURE (DEG C)

	936	~	~	0.5	~	~	0.20			1	0. 70		14.0				2.33	1.34	0	0.7	6.3	1.67	3.04		6.17		6.20	0.74	5.3	9	00.0	1.17	1.57	2.2	2.7	3.0	3.53	2.91	2.07	1:1	0.96	6.33	6.21		
	100	0.28	ñ.20	C.28	9.58	9.28	0.20				9.35	**	0.51	9.53	3.00	2.01	9.72	9.50	0.30	2.74	2.00	2.22	4.10	2.20	9.0			6.36	•	•		1.33	1.00	2.24	3.02	100	3.40	2.03	:	1.04	2.56	9.33	2.5		==
	1050	9.29	9.39		9-23	9.29	-	24.6		5	9.51			9.49	2.43	3.5			*		•			•	2.55		2.23	2.24	3.66	2		1.44	1.30	7							2.4	2.33	9.21		3
	113			•	•	r.32				•	0.53			0.76	6.50	6.62	6.67	9.0		9.1	:	3.56	4.62	3	0	C- 23		*	•	•	•	**	1.77	2.17	1.51		3.24			•	3.0	4.5	6.21		
	1158			C-26		•			2						1.45	C . 45	95.0	9.10	0.17	-	1.80	10.67	4.73	2.67			6.3	2.00	60	1.3	**	1.0	-	7:15	7.0		3.21	2900					~	-	::
	1200	P. 28	6.20	5.26	C.28	6.31	*							2.27	2.31	2.00	0.50	5	9	0		3.60		2.13	0.0	*	0.40	0.03				1.6:	1.10	2.5	1.37	3.0	3.26	3:	1:	5:1	3.5	6.33	9.21		
	1250			0.20							2.1			4.27	2.07	1.29	0.47	0.40	0.00	0.0	-	3.89	4.7	5.80	*			1.02		•	21.2	1.70	1.61	2	3.22		7.0				6.30	2.13	12.0		
	1 36M	0.28	0.20	0.50	0.28	0.20										•	9.51	0.45	3.0	1.16	2.1	3.8	4.76	2.43	1:1	2.5	0.0	2:	2.2	2:	2.12	8.2	2	2	3.03	3.63	7. 3.	2.71	2	8:			•		
	1356	0.28	0.20	6.20	6.2	0.7		2.47			27.5					1.27			0.0			3.0	4.17	3.0	1.22	0.67		2.53	•	•		2.33	:	2:	20.2	3.72	7.4	2.77	1.92	3					
	140			0.24		•						,	200	2.69	2.13	1.50	0.03	9.54	2.73	1.22	2:10	3.00	3.	3.13	1.3	0		3.24	•	•	•	~	~	<u>.</u> ,	 	-			-	÷	6	ė	ė	6	
WDAY)	1454	~	~	0.28	~	~					**	•		2.01	2.19	3:	1.11	0.74	C	1.20	2.16				1.3	•	2.22	*	5.27	4.82	3.62			•	2002	•	2.5			•	9.61	*	17.0		
CIPITATION (NOVDAY)	1504	0.28	0.28	0.28	9770	2.0		9	3	3						•	-	-	<u>خ</u>	-	~		*	÷	3:	÷	-	2.2	*	•	-	2.	-	<u>.</u> ,	**	-	3.52	2.	2.	-	•	ė	•	6	
Ħ	155N	0.28	0.28	0.20	0.28	0.23	•	, c	, .	•	8	•	~		~	2.19	-	_	1.27	_	~							6.30				~	_		2.53		3.5	-	~	=					
2 (DF)	3	0.28	0.20	0.28	0.28	0.28								3.12	2.6	2.13	=	-	1:1	نہ	~	-	•	i	2.10	÷	*	105	i	•	ń	~	.	- .	2.53			_	~		0	0	0 (96	
TARE S.	1654	•	i	ö	ö	9	•		•	•	2.6	•	•		~	~	~	_	3	_	~	-	*	-	3:	'n	*	÷		•		~	-	. .	2.51		7.7	4	2	÷	0	0	0 (5 6	
	1704	6.28	6.20	0.20	0.25	0.20	•) (<i>,</i> (•	3.3	•	700	~	~	×		-	•	_	~	á		+	3.31	į	•	2		•		_	-		3	•	3.73	_	~	-	•	ė	6	•	
	175W	•		0.28	•		•	,	,	•	2:39	•		~	~	~	~	-	1.76	-	~	-	•	÷	3.07	ř		4.31				~	÷	. .	***		3.72	_	~	_	•	•	7.0		
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		Ş	3	200	=	7		Į.			3	-		7	Ä	Ĭ	Ž	32	22	=	3	3	3	Z	2	3	105	148	25	225	2	2	7		33		I	916	22	3	765	3	100		*

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					•		•		0.0	2.5	•		0.70	•	2.00		2.17	3	
		2.0	0.20	6.20	•	0.20	•		•	0.20	6.30								
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	Į	3	1.11	1.33	3	1.70	•	2.22											
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	Ş	3	2.22	2.2	2.03	2.07		3-17			•							~	7.01
			200	*	2.2	1.5		2.37		3:2	•		8						
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	Ĭ	2.67	2.78	2	8														
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	7	0.22	0.23	0.27								2:	•	1	*		3.74		
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	×	0.30		3	0.00	6.20			1	3	6.23	0.30	9-24	9.50	6.3	6.92	74.0					8	6.73	*:	1	0.0		3.6	2		46	2.2	2.7	2.13		4		0.10	C. 1.	0.11
	3			3		2.5				3	ć	2.3	2.27	9.0	2.20	9.0					20.0	9.01		9.11	2.	1	9.50	9.6	3.			2.72	2:			14.6	2	0.10	2::	9.11
	ž	2.29			2.1	25.20			9.5	1		3.43	2.13	2.0	6.50	2.5						\$?	2:	2		2.35	400	:	1.50	==	2:			55	3.61	2	9.10	2.10	•
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	5	9.50		6.53		0.20				6.33			6.03	-1:	0.00	29.0			1.00	2		9.40	•	===	3.00			1.22		2		2.3				14.0	×	6.10	6.1.	-
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	*	23			•	1:			:	0.03	19.0		5		2.0	2:			0.20	6.5	*	0.91	:	2.33	2		22	2.6	7.0.	2.10	12	2:			12	10.0	×	0.10		
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MECIPITA	ž	0.20	1		2	2:					20.1	3		:	2.	2.0		:		2	3.2	3	3.70					2.2	:			2:	:: ::			3.	0.20			
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TABLE 5.2	196	23	0.9						=				2:	•		2:0		2	0.23	3	==			100			6.27	2:	0.72		200	2			3	:	0.7	::		
-	0	2.0				21	2		•	1.67	2.33	2.17	3		0.27			:	0.24	2:	2:	2						2:	1	:		2.					2	2:		
	*	2.3	3				2.5	4	•	3.2	2.10	3	*:		0.20			•	0.24	:	2:2	2:		0-11			7	***	3	2:		8:2		111		6.33	0.30			
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		7	2				= !		-	= :		*			i i	2	2000	3
	2.23	:		2	12	2.70		-	3	25.			1.22		1			0
	3	2.01	2.02	2.63	3:2		2:	9.13	2.03	3.21	3	2.47	1.30		-1.5	10.1	1:10	1.22
	2	3:	*	2.5	*		3.3	2.3	3.4		3:		1.37	1.39	1.23	1.23	1.32	1.37
	~~	?	1.7	1	-	3	1	2.5	2.5	\$	2:	-		-	21-1	2.5	-	-
								~	:	25		8				~	3:	2
I			2	3.5	2	2	8	3		5.6	2				. 0			
	2	3-21	4	2.02	20.70	2007	2010	2.63	20.7	\$	1.23	0.0	3	6.00	1.5	16.51	1.71	2.74
	1.72	2.05	2.57	2.45	2.32	2:2	\$	2:	1.57	2	8	1	0.77	3.0		2	3	2.10
_	1.57	2.51	2.42	2:2	2:	2:2	\$	3:	10.1	27:	×:	1.20	-:	-	1.20	2.10	1.37	2.67
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	2.3	2.4	*	5.63	3.35	2.00	4.05	2.51	2.03	2.2	5	1.07	1.91	1.19		9.00	3.5	0.31
	\$	69.0	•••	16.91	•	3.47	9.01	4.33	2	3.77	7.0	2.05	2002	2.12	1.02	1. 32	1.03	
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TABLE 5.28. ANNUAL PHECIPITATION (POYDAY) (NEVISION OF TABLE 5.48 OF SCHOTZ AND GATES, 1971)

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106	3	0.00	•			•	0.10	•	•	0.10			9.50	•	•	•	•	9	0.0	0	0	0		0.07	•	•	•		0.09	0.00	0.20	0.50	0.20		0,00		•	•		0.21	0.0	000		0.07	0.45	0.45	0.80	0.80	0.80	
755		000		•			0.10	•					97.0	;∙	₹.	; -	-	•	90.0	•	•	•		90.0	•	•		•	•			90.0	•		90.0	•	•	•		40.0	•	•	•	•	4	0.45				a
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12 N		000	0.70	0.10	0.10		0.10	-	-	9	M	•	94	-	•			0	0.0	0	0	•		90.0	•	•	•			•	•	90.0	•	•	90.0	•	•	•	•	80.0	c	C	0	2	4	0.45	8	8	8	8
*0				-	-		2:0		2	000	0.32	•	24.0			9		0	0.08	0	9	9			•				90.0		•	•	•		90.0	•	•	•	9	0.08	0	0	0		*	0.45	8		8	8
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TABLE 5.3 JAN SUNFACE ALBEDO (FRACTIONS)

	8 SE	000				0.70	4	0.44	44.0	0.28	2	4	Š	0.30	•			9	0			90.0	•	•		•	•	90.0				0.07	0	•	0	0.09	•	4	*	•		000
	80E	0.80		•	•					•	2			0.20	•		17					90.0		•	•		•	90.0		•	•	0.07	0	0	0	0.09	0	*	4			0
	75E	0.80				0.70	2.0	9446	9.44	9.69				0.29 9.19	1			7	0.19			90.0	•	•		•	•	0.06				5.97	· .	0	5	65.0	ç	*	*	•	æ.	9.90
	70E	000			•	0.70	0.0	0.44	44.0	0.60				0.20			•		0.01			90°C			90.0	90.0	90.0	90°0	90-0	90.0	90.0	0.07	•		•	0.09	•	*	*			0000
	65E	000		~		0.70	0.70	44.0	94.0	0.00		•		0.20				,	0.0			0°0	•		90.0	90.0	90°0	90.0	C	:0	•	0°07		0	0	60° J	Ç	*	4			0.80
	60 E	0.0		•	•		0.70			•			•	0.3C	1	0.20	•	•	6.67			90.0	•	•				0.0				0.07	•	•		0.09	•	0.45	0.45	0.00	0.80 0	0.00 0.00 0.00 0.00
	35E	000					20.0	S		*				0.20	1				0.07			90.0				•		000				0.07	•	0	0	0.09	*	•			•	000
	50E	000					200						•	o.10	1				0.07			90.0		•	•	•	•	000				0.07	•	•	•	0.09	7				•	
	45E	000					0.50						•	0.10			•					0.10		•				90.0	•	9	9	0.07				0.09					•	000
	40 €	0.0		~	7		0.25				Ŋ		7	0.10	1	02.00		•	0.10	7	7	0.10	•	•				000				0.07	0	0	0	0.09	•	*	*			0.00
TIONS)	35E	000	• •				05.0			•	1		7	0.10			•		0.10	~	7	0.10	•	•	0	0	•	90.0				0.07	•	•	•	60.0	0					000
ALBEDO (FRACTIONS)	30E	9.0					*				*	*	∹	••• •••			•		0.10			0.10		•		•	•	99		•		0.07	0	0	0	0.09	•	•	•	•	•	000
ų	25E	000	• •		•		0.35				4	7	7	0.10			•	•	0.20			0.10		•	•	•	•	91.0			•	0.07	C	0	0	0.09	0	•	•	•	•	
JAN SURFAC	20E	000	• •		•	-	0.35		*	*	*	7	7	0.13		0,00	0.20	0.20	0.20		7	0.07	ô	•	0	0	٠.	0.18		-	•	0.07	0	0	0	0.09	9	*	4	•	•	000
TABLE 5.3	156	9.0	• •				0.70			•				99			•			7	7	0.07	0	9	0	0	7	0.18	9	9	°	0.07	0	9	0	63.0	٠	0.45	0.45	0.0	0.60	9.0
7	106	000			•	•	0.22	3	7	-	•	•	•	o.10	1		•			7	7	0.07	0	9				900	•	•	•	0.07	0	0	0	0.09	•	*	4		•	000
	SE	000					0.22	2	7	-	-	-	7	01.0		02.0	0-20	0.20	0.50			90.0		•		•	•	90.0	•		•	0.07	0	o.	0	0.09	٠	4	*			000
	0E	000				-	0.22		7	7	7	7	7	0.0	1	0.30			0.20			90.0			•	•		90.0			•	0.07	0	0	0	0.40	•	*	•			000
		NO6	62N	3	74N	707	Z	62N	N	241	20N	Z	42N	36Z	3	2 4 4	22N	Z	Z +	NOT	3	Z,	28	Ş	0	4		265	306	348	388	428 465	505	248	588	625	999	705	245	785	872	908

175E	0.00			6		0.20	0.19	0.18	-	: 7	7	0.11	•	0	9	, (0.00	!	90.0	000	900	90.0		•	•	•	90.0			•	0.07	•	C	0.08	0	0	0	4	1	•	•	0.00	9
170E	00.80		2 60	6	200	0.70	0.19	0.18		•	•	0.11	•	0	0	30	0.0		900	•	•			•	•	• •	90.0	3	900	90.0	0.13	0.07	0	0.08	0	0	0	*	*	*	*	0.80	
1656	0.80	8		9	: `	9.79	7	7.	7	7	7	0.13		ç	ç	9	0.07		9000	•	• (•	• (0.06		• (•	10.0	•	٥.	90.0	5	ç	င့	*	*	*	*	0.00	•
160E	00.0	•	• •			0.32		•	7	7	7	0.11	}	0	ç	•	0.0			• •	•			•	• •		90.0	C	9	9	0.07	ပ္	•	0.08	•	•	•	•	•	•	•	200	•
155E	0.80	80	. w	-	~	0.32	924 0	7	7	7	7	0.10		0	9	9	0.07	è	900	90.0	90.0	90.0	6		90.0	90.0	90.0				0.07	•	Ç	90.0	0	0	ç	*	*	80			•
150E	0.80 0.80	•	• •	7		0.32	7	7			•	0.11		•	•	• •	0.07		900			•		90.0			0.09				0.07	•	0	0°0	۰	۰	0	•	•	•	•	000	
145E	000	8		7		0.32	7	∹	7	7	7	0.10					0.07		90.0			•		900				•		•	0.13	•	0	0.08	0	0	•	*	*	8	9	0.80	
140E	0.80		•			9.32	7	7	₩.	٦.	∹.	90.0		•	•		0.07		90.0			•	•	90.0		•	•	•		•	0.07	•	•	0.08	•	•	•	•	•	•	•	90	•
135E	0.80	8 8	8	7	.3	0.32		Ō		e.	∹-	0.10		600	• (900			•	•	0.10				•	•	•	0.07	•		80.0	ô	٠,	•	•	•	•	•	0.80	
130E	0.80	20 00	8	64		0.40	3,	ů	4	*	፣ -	0.10		600		0	0		90.0	•	•	•	9	0.10		٣.	7			•	0.07	•	0.07	•	•	•	•	•	4	9 9	9	8	
125E	000	9	8	-		0.32	•	•	4	4.	₹ 7	0.10	•	600	0	0	•	•	90.0	•	•	•	0	90.0	•	7	∹	7	•	0	0.0	•	0.07	0	9	Ò		0.45	•	9 4	. 4	8	
120E	000	9	8	7.		0.32	•	•	*	4.		0.10	•	0.10	0	0		•	90.0	•	•	•	0	90.0	0	7	~	0	0	•	000		0.07	9	Ò	Č	•	9.45	•	•	8	8	
1156	0000		•		•	0.32	•	•	4.	٠.	51.0	7	•	0	: 0	0	0		0.0	•	•	•	•	90.0	•	•	•	•	•	•	0.0	•	0.07	•	9	4		0.45	•		8	8	
110E	000	8		~	٠,	0.32		•	•	•	0.20			01.0		•	•	•	90.0	•	•	•	•	90.0	•	•	•	•	•	•	0.0	•	0.07	9	9	4	:	0.45	•	Ø	80	ĕ	
105E	000				ů,	0.32		•	84.0	•		•		0		•	•	•	0°0	•	•	•	•	90.0	•	•	•	•	•	•	0.0	,	0.07	9	9			0.45	•			•	
100E	00.00		~	7	m r	0.32			0.28	,,		2	•	0.0	7	7	0	0.0	0.10	0.0	90.0	0000	•	90.0	•	•	•	0	9	9	0.0		0.07	9	9	0		0.45		8	8	8	
95E	0000		~		•	0.44	•		0.28	•	7	.2	•	0.07	7	7	•	•	90.0	•	•	•	90.0	90.0	•	•	•	•	•	•	0.07		0.07	0	0	0	•	0.45	8		8	æ	
90E	000		~	0.70	•	• •	•	•	0.28	,,	7	.2	•	20.0	0	•	•		90.0	•	•	•	90.0	•	•	•	•	90.0			•	•	0.09	9	ó	Ö	•	0.0	8	8	8		
	N 20 20 20 20 20 20 20 20 20 20 20 20 20		4	10N	Z 2	2 8 N	242		N 2	2	3 8 N	34N	202	20 N	22N	Z	Ž	NO	Z :	2 6	SY	3	50.	3	200	3 4	3	500					\$ Q				ě	34	88	52	9 2	ŝ	

TABLE 5.3 JAN SURFACE ALBEDO (FRACTIONS)

•		•	****	:														
	9.58	9.57	0.57	0.56	0.56	0.56	0.55	0.55	0.55	0.55	0.56	0	o į	- 1		0.57		?
0.55		•	0.55	2	0.54	0.53	0.53	0.53	0.53	0.53	•	0.53	0.54	0.54	0.54	0.55	0.55	202
î	Ŷ	٠.	·	•	16.0	10.0	•	0	•	•	•	Ď	•	•	en .	•	•	•
ŝ	ŝ	ů,	Š	4		9. t	•	200	•	•	•		•	•	•	•	• •	V 4
•	*	4	•	4.	9 .	9.40	•	\$. \$.	•	•	•	•	•	•	•	. 4	ţ٠	96
4,	4.	•	•	4	1	0	•	24.0	•	•	•	9	•	•	•	•	•	
0.42	9.42	9.43	0.42	C.42	0.42	14.0	14.0	0.40	0.39	0.38	0.38	0.37	0.36	0.36	0.36	0.36	0.36	505
4	4	•	•	4	m	ι.	•		•	•	•	•	•	•	•	?	?	0
Ę.	9.37	9.37	C.37		0.37	٠	0.37	٠,	۳,	٠,	•	ů,	•	•		0.29	7,	N
ŗ.	ŗ.			•	•	J.	•		•		•	3	•	•	7	7	7	9 (
Ψ,	6				m 1		•	Ų.	ů		•	•	•	•	7	7	'n	•
0.29		9.39	r.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.29	0.28	0.27	0.26	0.25	308
!	•	•	•	•		1	•			!								
	•	`	•	•		2	•	•	7	7	.2		•		0.27	0.26		ø
C - 20	0.20	9.22	75.0	0.25	0.25	0.25	0.25	0.25	9.25	0.25	0.26	0.26	0.27	0.27	0.27	0.28	0.29	225
2	•			•	2	2	•		2	7	7		•		0.29	0.30	•	•
7		7			N	~			2	7	.2		•	•	0.29	0.30		•
7		7			-	_	•		~	~	Š		0.27		0.30	0.30	0.32	0
7	-	=:	7	7	7	_	•	7	~	7	~	7	0.27	•	0.30	0.32	•	6 S
7	7	٦.	٦.	٦.	٦.	_	•	٦.	~	7	7	7	0.27	•	٥٤٠	0.33	•	52
0.19	9.17	9.16	ن•10 د	C-14	0°19	0.19	0.20	0.20	0.21	0.22	0.25	0.25	r.27	0.29	0.30	0.34	0.35	2N
-	: -	: -		. ?	. ?	10	1	7	10	2	N	7	0.27		0.30	0.33		3
	-			3	3	~	•	3	~	2	2	2	0.27		0.30	0.31		Z
~	~	Ç	•	•	C. 25	~	•	~	0.25	~	•	• 2	2	•	0.30	•	•	Ž,
0.25	0.25	9.25	C.26	r.27	r.27	0.28	0.29	0.29	0.28	0.27	0.27	0.27	0.28	0.29	0.29	0.29	0.29	Z .
			•		C. 30				0.31			6	.2	•	0.29	•	2	22N
		7	•	•	5. B.S.			6	0.33						0.30	•	6	79
*				•	C • 40	4			0.37				٣.	•	0.33	•	٤,	NO
•	4	*	•	4	u•42	•	•	•	0.40	•	•	•	•	•	•	•	0.33	Z
•	•	•	•	٠,	C + 5	•	•	•	14.0	*	•	•	•	•	•	•		200
0.51	9.51	9.51	15.0	C.51	O. 50	•	•	0.45	4.0	0.43	•	4	0.45	0.42	•	•	0.42	17N
ŝ	ŝ	ŝ	ŝ	'n	C.52	•	•	•	9.40	4	•	*	*	•	•	•	0.45	Z .
0.59	5	.5	Š	5	0.59	n. 56	0.52	0.50	0.49	*	0.48	0.48	.9		0.49	0.49	0.50	NOS
•	•	•	0.00	000	0	0.0	•	•	0.52	ŭ	n	^	C	•	0.0	•	5	2
9	9	•	09.0	0.59	ر د د د	0.63			0.55	Ň	'		١٠	•	0.58	•	•	Z S
9	9	•	0.0	65.0	ن ن•ون	0.60	•	•	0.60	9	•	•	9	•	09.0	•	•	82N
0.00	0.60	9.59	0.59	65.0	65.0	0.59	0.59	0.59	0.60	09.0	09.0	0.59	0.59	0.59	0.59	0.59	0.59	7 S
#	:	4	******	*****	***	******	-		*****	*		# 1	*****	*****	******		**	Š
					***								\(\frac{1}{2}\)				****	ž
****		*******	*******	******	*******			********		*******	*******	****	********		*******		* *	BN+
		***	*	*											*********	*******		2
1												- 3		4	******		*****	3
MS6	100M	10 SH	1104	1154	120H	125W	130W	135W	-140M	145H	150%	155W	16CK	165W	170W	175W	1804	
										•								
										7251-75	2							
										ALBEDO (FRACTIONS)	LBEDO (F	ETARY	JAN PLAN	TABLE 5.4				

0.00 0.40 0.00 0.00 0.40 0.40 0.40 0.40	0000 0000	!!!!	*******		9	-	1	1				******	******	*******	*******	ä		
0.00 0.00 <th< th=""><th>0000 0000 9999 WWW.</th><th>******</th><th>******</th><th></th><th></th><th></th><th></th><th></th><th></th><th>HH</th><th></th><th></th><th>******</th><th></th><th></th><th></th><th></th><th></th></th<>	0000 0000 9999 WWW.	******	******							HH			******					
0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.55			******		****	*****	******		- 4									
Color Colo		9.0		0	0.6	9.0	09.0				3		****		•		******	*****
Colored Colo	00000	9.0		.	9.0	9.0	0.60		9	09.0	•	•	5 (•	•	09.0	0.60
Color Colo	0000			0	9.0	9.0	09.0		9	09-0			ى د	۰	•	Ø 1	0.60	0.60
0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.55				0	9.0	9.0	09.0	•	5	0.56			9 6	ņ	•	n (0.58	0.5
0.55			•	•		,						:	•	ñ	•	•	0.52	0.52
0.45 0.46 0.46 0.47 0.48 0.47 0.48 0.44 0.44 0.44 0.44 0.44 0.44 0.44			0 0		ů	0	•		0.50	0.50	•	-	0.68			,		
0.45 0.46 0.46 0.45 0.45 0.44 0.45 0.44 0.45 0.45 0.45			0 0	0,0	•	0.0	•	*	0.47	0.46	•			•	•	14.0	0.47	•
0.45 0.45 0.45 0.45 0.45 0.45 0.44 0.42 0.44 0.40 0.49 0.49 0.49 0.49 0.49 0.49					•	•	•	*	0.44	0.43				•	•	***	1.0	•
0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45				0	•	••	•	*	0.40	0-40				•	•	2.41	0.41	
0.25 0.25 0.28 0.39 0.39 0.39 0.39 0.39 0.30 0.30 0.30	•		•	•	4	4.0			0.37	0.36		1	0 · C	•	•	0.38	0.39	
0.25 0.25 0.28 0.30 0.35 0.35 0.35 0.35 0.35 0.30 0.29 0.29 0.29 0.29 0.29 0.29 0.29 0.2	4	4	•	•	•									•	•	0.36	0.36	•
0.25 0.25 0.28 0.30 0.35 0.35 0.35 0.34 0.30 0.30 0.30 0.29 0.29 0.29 0.29 0.39 0.39 0.39 0.39 0.39 0.39 0.39 0.3			•	•		~	~	ņ	5			*		•		•	1	
0.25 0.25 0.28 0.30 0.32 0.33 0.32 0.33 0.29 0.29 0.28 0.25 0.27 0.26 0.29 0.39 0.39 0.39 0.39 0.29 0.25 0.25 0.29 0.39 0.39 0.39 0.39 0.39 0.39 0.39 0.3) "	֓֞֜֜֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֡֓֓֓֓֓֡֓֓֡֓	•	•		~	٠.						•	י פ	•	•	M	~
0.25 0.25 0.28 0.39 0.35 0.33 0.31 0.30 0.29 0.28 0.25 0.25 0.25 0.25 0.25 0.25 0.28 0.28 0.29 0.28 0.29 0.29 0.29 0.29 0.29 0.29 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.29 0.39 0.30 0.29 0.20 0.25 0.25 0.25 0.25 0.25 0.25 0.25	•	֓֞֜֜֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓	•	.	•	ņ	۳.						•	,,	•		m.	ů.
0.25 0.25 <th< td=""><td>•</td><td>7.0</td><td>•</td><td>•</td><td>Ψ,</td><td>ņ</td><td>#13 #</td><td></td><td>7</td><td>•</td><td></td><td>9</td><td>•</td><td>7</td><td>•</td><td>W.</td><td>ņ</td><td>Ę,</td></th<>	•	7.0	•	•	Ψ,	ņ	#13 #		7	•		9	•	7	•	W.	ņ	Ę,
0.22 0.25 0.29 0.39 0.39 0.35 0.35 0.39 0.30 0.29 0.28 0.27 0.27 0.22 0.21 0.29 0.29 0.29 0.29 0.29 0.29 0.29 0.29		7.0	•	ċ	~	٣,	6	7			•	•	•	7	•	4		
0.25 0.28 0.24 0.30 0.31 0.35 0.35 0.35 0.34 0.20 0.28 0.26 0.26 0.27 0.25 0.21 0.20 0.29 0.25 0.22 0.20 0.29 0.25 0.22 0.20 0.29 0.25 0.22 0.20 0.29 0.25 0.22 0.20 0.29 0.25 0.20 0.20	•	,	ì							•	•	Ž	•	?	•	.2	7	
0.20 0.25 0.29 0.39 0.34 0.37 0.38 0.36 0.39 0.39 0.29 0.29 0.25 0.21 0.22 0.21 0.22 0.22 0.22 0.22 0.22	7	0.2	ċ	~	۳,		0.35		Ç			•						
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TABLE 5.4 JAN PLANETARY ALBEDO (FRACTIONS)

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TABLE S.4 JAN PLANTARY A. TO (FRACTIONS)

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